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Class 12 « Atlantic » locomotives(*)

Belgian National Railways Company,

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Frame.

The frame consists of two longitudinal bar members, which are braced by the cylinders, and a long mild steel box-pattern cross frame placed under the firebox and extending to the rear head-stock. Although this box-pattern cross frame is difficult to cast, its weight is very much less than that of assembled sections staying the main frames and extending to the rear, especially, as is the case here, if a good cross-stiffening arrangement must compensate for the local reduction in height of the frame members due to the use of an overhanging firebox.

The boiler is secured to the base made up of the upper saddle of the block of two cylinders and is connected with the back of the frame by two lateral slide plates arranged under the front water leg of the firebox. In addition to these main fixing points, the boiler also rests on an inside support of the motion and is also attached to the frame by two flexible plates placed on edge, one under the central barrel ring and the other under the rear water leg of the firebox.

Taking the hornblocks as forming an integral part of the frame, the latter has been calculated by comparing it to a Vierendeel girder. Three hypotheses of stresses have received attention : (1) vehicle resting on rails, (2) vehicle raised by the front end, and (3) vehicle raised by the back end.

These calculations have enabled the proportions of the upper and lower bar members and also the uprights to be better judged, and a lighter construction to be obtained than with the American standard practice, as reference to Fig. 4 will show. The boiler is in the background.

Springs and gear. — Laminated springs are arranged over the axle boxes of the coupled wheels and transfer their load thereon by means of hangers. The forces are transmitted without overhang and all the details are easily accessible.

(*) Concluded from page 44, February 1940 number.

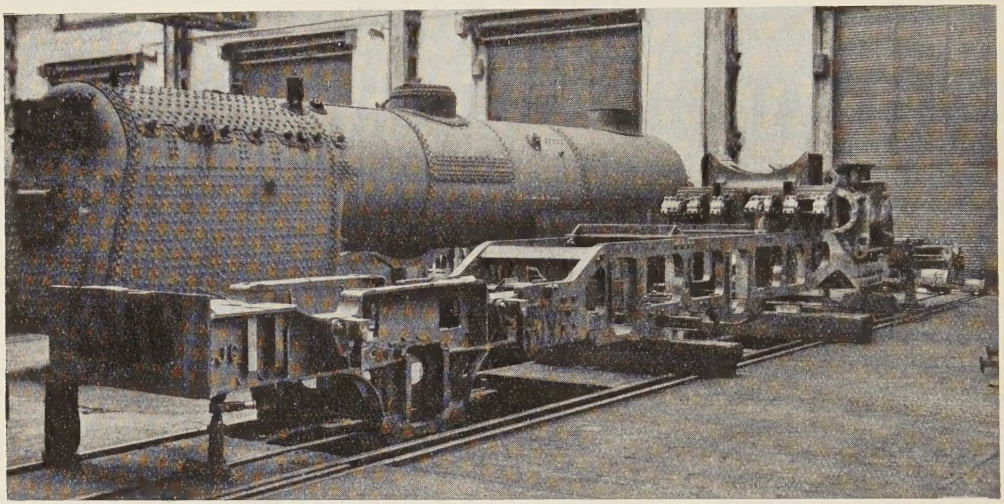

Fig. 4.

The use of longitudinal equalisers between the coupled driving wheels and trailing pair of wheels enables an equal distribution of the loads on the track to be maintained.

As it was a question of prototypes of locomotives, two slots arranged on either side of the articulation pin of the back equaliser would have allowed the distribution of the loads to be perfected, if necessary.

The bogie suspension is carried out by means of two laminated springs placed longitudinally on the right and left double flanged hangers.

Bogie. — The Delta type bogie of the Commonwealth Sales Corporation gives constant centering forces of 7 300 kgr. (16 100 lb.). The centre pin socket can be moved 105 mm. (4 1/8 in.) on either side of its central position and the cor-

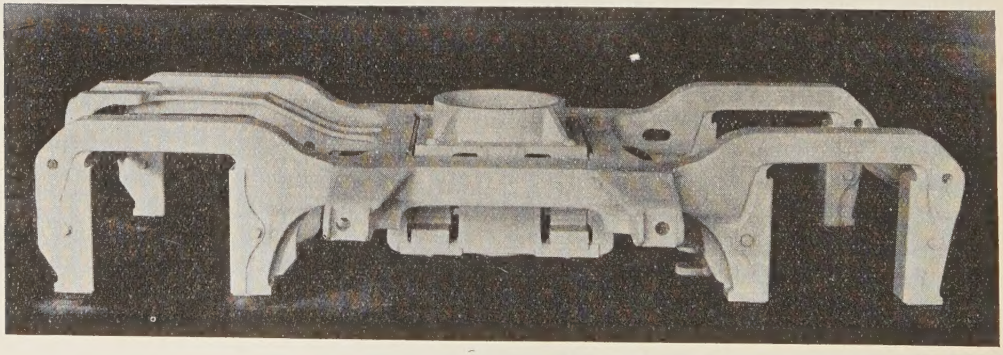

Fig. 5.

responding raising of the front of the locomotive is 42 mm. (1 21/32 in.).

As shown in Fig. 5, the bogie frame, which is a one-piece steel casting, gives the impression of very light construction, but it has proved itself on the class 1 locomotives.

Wheels and axles. — The crank axle is built-up of 5 parts, balanced for rotation. The cranks are in semi-hard steel quenched and tempered, and the special steel webs are also heat treated. The shape of the webs was designed only to enclose the cranks in a thickness of metal just sufficient for good assembly. The bending stresses in the axle give rise to modifications of the compression stresses in the wheel seats which justify a maximum thickness of 115 mm. (4 1/2 in.) of the webs, which thickness also depends on the alignment of the centre lines of the cylinders and main frames, as well as on the minimum lengths of the journals determined by overheating conditions.

In order that the cranks shall always remain under sufficient compression in the webs, very good fixing was essential, which necessitated shrinking on. A shrinkage of about 2/1 000ths could be guaranteed by specifying tolerances of grades 7 and 6 of the I. S. A. for the male and female parts respectively, as well as getting the very finest finish of the surfaces in contact.

This strong shrinkage develops, in the sections of the webs between the cranks, stresses which are likely to exceed the elastic limit of carbon steels, and increase as the webs become closer. The spacing of the latter has been a factor in the determination of the radius of the crank and consequently of the piston stroke of 720 mm. (28 3/8 in.). This strong shrinkage, moreover, justifies the use of special alloy steel, the composition of which ensures the heat treatment penetrating throughout the metal.

The location of the balance weights as far from the centre line as the proximity of the details round the crank axle allows has determined the cross section of the webs.

The resulting wheels and axle, as shown in Fig. 6, gives the impression of a part the various components of which have been carefully proportioned.

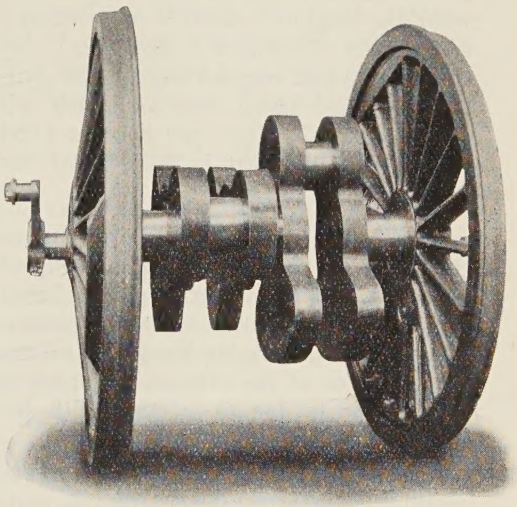

Fig. 6.

The wheel is pressed on the axle cold, with a fit of approximately 1.7/1 000ths, and Nos. 6 and 7 tolerances of the I. S. A. likewise.

The straight axles are of semi-hard steel, quenched and tempered. They are bored and have no collar.

The coupled wheels have their bosses protected inside against wear by a large annular plate of hard heat-treated steel against which the axleboxes rub when working round curves. The estimated

balance weight in the plane of the centre line of the cylinders at the crank radius, which balances the effect of the reciprocating masses, is 82 kgr. (181 lb.). When transferred to the centre line of the wheel, at a distance between wheel centres of 1.580 m. (5 ft. 2 13/64 in.) the weight is reduced to 61.3 kgr. (135.1 lb.). Combined with the balancing weights of the rotating eccentric masses, it shows that the most effective balance weights are in the form of segments 176 to 179 mm. (6 15/16 and 7 3/64 in.) wide, the height of which is only 107 and 94 mm. (4 13/64 and 3 45/64 in.), for the driving and coupled axles. The dynamic overload which results on each rail at 140 km. (87 miles) per hour is 3 080 kgr. (6 790 lb.) that is 26.8 % of the static load.

Axle boxes. — The axle boxes are of cast steel. The axle brasses of the coupled wheels are of the American type, being semi-cylindrical and without cheeks. Phosphor bronze liners are placed on the outside faces of the oilboxes in order to take the wear due to friction with the wheel centres.

The higher rotational speed of the rear carrying axle gives the journal a peripherical speed of approximately 7.75 m. (25 ft.) per second at 160 km. (100 miles) per hour and increases the quantity of heat to be dissipated. This drawback is the more accentuated as the box is located in a recess in the ashpan and is, therefore, less able to cool off. With a view to reducing the specific pressure of the axle brass on the journal, the latter is very long and, in order to maintain this pressure as uniform as possible on the whole of the bearing, it has side cheeks which diminish the deformation by transverse bending.

Lubrication of both the coupled and trailing carrying axles is carried out by means of a mechanical lubricator forcing the oil to the upper part of the boxes. Whereas the oil groove of the coupled pairs of wheels coincides with the upper generatrix of the journals, as on all Belgian locomotives, the oil groove for the carrying axle had to be removed as far back as the generatrix of the origin of the seat, when running forward. The customary supplementary lubrication by wool waste and horsehair packed in the lower box could not be relied upon to form the oil film at high peripherical speeds.

The bogie wheels which revolve at still higher angular speeds have roller bearings. They are fitted with two rows of self-aligning rollers.

Motion.

Cylinders and Walschaerts valve gear. — The cylinders are of cast steel melted in an electric furnace, and are of the same metal as that used for the important frame parts, i. e. : — breaking strength 50 to 55 kgr./mm^2 (31.75 to 34.9 tons/sq. in.), elongation at least 20 %. They have a cast iron liner 16 mm. (5/8 in.) thick.

The staying they provide in front of the locomotive frame is much more robust than when made of cast iron, and if necessary can more easily be repaired by welding.

The bar frames enable the cylinders to be securely fixed. From the driving axle, the upper bar is carried down to the lower bar to form a single member which is then carried upwards to the level of the buffer beam. This member forms a very strong horizontal seating at the end of which two shoulders are easily formed. The cylinders are secured thereto by means of two vertical fasten-

ing pieces which are made rigid by three transverse ribs. Sixteen 35-mm. (1 3/8 in.) diameter bolts fix each side of the fastening pieces to the member. A 70-mm. (2 3/4 in.) diameter water relief valve is fitted at each cylinder head. The drain cocks have valves of rustless steel, and can be worked by compressed air servo-motor from the cab.

The cylinders are lubricated by one of the two compartments of two *Friedmann* mechanical lubricators, each of which has 6 feeds. The other compartment of these lubricators lubricates the running gear and motion.

The cylinder lubricating pipes are connected to steam atomisers placed right above and a short distance from the cylinders. Four feeds lubricate each of the piston valve pistons, the oil being forced through the liners on the inner side of the steam ports. The four others are connected to the front and back of the two cylinder barrels at the point of maximum pressure. The four remaining feeds lubricate the piston rod stuffing box to the inside of the cylinder cover and the tail rod sleeves.

The principal dimensions of the cylinders are of interest.

First, taking the diameter d and the radius of crank $\frac{L}{2}$ on the one hand, considered correlatively to the pressure p and the diameter D of the driving wheels, they give, by the usual formula :

$$T = \frac{.75\ pd^2\ L}{D},$$

a mean starting tractive effort of :

$$\frac{0.75 \times 18 \times \overset{-2}{48} \times 72}{210} = 10\ 664 \text{ kgr.}$$

The ratio of 4.31 of the adhesive weight of 46 metric tons to this effort is satisfactory.

Secondly, the proportion of 111.2 sq. cm. per cu. dm. of the volume swept by the piston in relation to the volume of the cylinder established by Herr Nordmann, can be adopted.

Thirdly, in order to determine the tractive performance which the locomotive would satisfy at the maximum speed of 150 km. (93 miles) per hour, that is to say, about 380 r. p. m., it was calculated to maintain a nominal cut-off of 25 % and to obtain a ratio of about 40 % of effective effort to the maximum theoretical effort $\frac{pd^2L}{D}$. It was understood, and experience has confirmed it, that for a new streamlined locomotive having only four coupled wheels, the mechanical efficiency, that is the ratio of the useful power to the power in the cylinders, would be, under these conditions, at least 40 %.

This computation was confirmed by the working out of a theoretical diagram drawn when selecting the elements of the valve gear and also by calculating the corresponding steam consumption per indicated horse-power/hour, and taking into account the maximum steam production which could be expected from the boiler.

It was also desirable to be able to reduce at high speeds the cut-off to 15 % and even, in exceptional cases, to 10 %. With this object in view :—

(1) The arrangement of the valve gear had to give the valve a long travel so as to increase the port openings as much as possible.

(2) The lead and the inside and out-

side laps to be adopted had to permit of satisfactory events for the valve gear, even with such early cut-offs.

Steam ports and openings as short, direct and wide as possible were also specified so as to limit as much as possible the loss of pressure, without their volume unduly increasing the clearance.

Experience with earlier locomotives encouraged the use of a piston valve with a maximum travel of approximately 200 mm. (7 7/8 in.), whilst endeavouring to maintain equal admission on the two piston faces. The incorporation of this feature was facilitated by the use of a model valve gear. In addition this enabled the positions of the pistons nearest the dead centres to be determined accurately.

The arrangement of the valve gear had also to allow for the placing of the valve sufficiently far from the centre line of the cylinder in order to make the valve gear of such size as would allow of the necessary areas for the steam passages. These considerations led to the choice of piston valves having a diameter of 360 mm. (14 3/16 in.) and constructed very lightly of welded plate so as to reduce inertia. In spite of this very large diameter and a head 120 mm. (4 23/32 in.) long with two rings on the exhaust and three on the admission side, the piston valve shown in Fig. 7 only weighs 19 kgr. (41.9 lb.).

The steam passage in the cylinder round the valve liner ports has been designed with the greatest care. Its section progressively increases from a point opposite to the cylinder and is made equal to that of the ports with which it communicates. Its output coefficient is calculated as 0.85 and this proportion was adopted as the ratio of the area of the ports to the section of the pipe which joins them to the cylinder body.

In spite of the large size of this pipe and the port mentioned above, their aggregate volume, including the space enclosed up to the ports in the liner, is only 10 % of the swept volume. The volume of 3.3 dm^3 (201 cu. in.) of the space between a cylinder cover and the piston in its position at the end of the stroke, added to the above, produces the clearance of 12.5 %.

To find the best values for the inside and outside laps, and also the lead, we found it convenient to use Dr.-Ing. Werner MULLER's tables (1).

First of all 3 theoretical indicator diagrams were drawn with 0, 5 and 10 mm. (0, 3/16 and 3/8 in.) exhaust laps respectively. For these diagrams the zero point was taken at the exhaust period during which, for a given position of the piston, the content of the cylinder and also the mean pressure and temperature of the steam were known. By developing the steam adiabatically and calculating the discharge of the outlets pro rata with their openings and the pressures on both sides, it was possible to dertermine by successive approximations, for elementary movements of the pistons, the pressure and temperature conditions of the steam. In this way the pressure-volume curve of the theoretical graph was obtained, and at the same time the amount of steam passing from the valve to the cylinder.

In short the power developed in the cylinder and the amount of steam necessary to produce it have been determined correlatively and, as a result, the theoretical steam consumption per I. H. P.

For example, at a speed of 150 km. (93 miles) an hour with an absolute

(1) Cf. *Organ für die Fortschritte des Eisenbahnwesens*, 15th January, 1937.

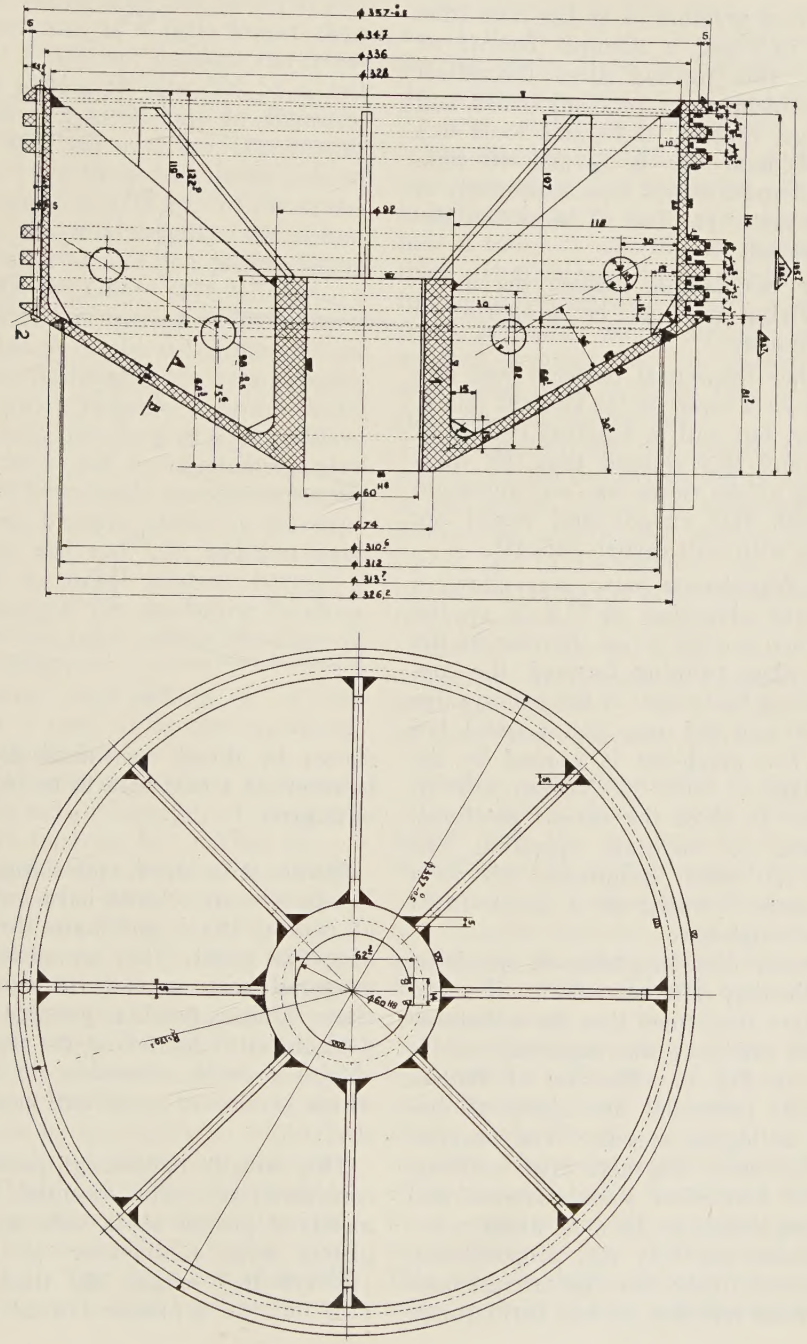

Fig. 7.

steam chest pressure of 18 kgr./cm² (256 lb./sq. in.) and a nominal cut-off of 26.4 %, this method gives theoretical steam consumptions of 6.661, 6.342 and 5.938 kgr. (14.685, 13.98 and 13.09 lb.) per H.P.-hour for 0, 5, and 10 mm. (0, 3/16 and 3/8 in.) laps respectively at the exhaust. The last of these was the one selected.

These calculations enabled the boiler and driving gear to be proportioned harmoniously.

Another theoretical diagram was also got out for a speed of 150 km. (93 miles) an hour, but with a nominal cut-off of 15 % and this showed that the wire-drawing of the steam was not unreasonable with this cut-off and would not even be with still earlier cut-offs.

The Walschaerts valve gear allows a maximum admission of 71.5 % on the front face and 69 % on the rear of the piston when running forward, the corresponding half-travel of the piston valve being 95 and 105 mm. (3 3/4 and 4 1/8 in.). The weigh-bar is worked by the usual type of screw mechanism with an indicator to show the cut-off positions. In order to facilitate operation, the driver can admit compressed air in a servo-motor working on a crank fitted on the weigh-bar.

Indicator diagrams taken at speeds of approximately 110 km. (68.3 miles) an hour have confirmed that the wiredrawing was small, as was expected, and as shown in Fig. 8. The use of Maihak apparatus prevented the taking of diagrams at higher speeds. The examination of these diagrams also confirms that the admission leads, exhaust lead and compression at the most usual running notches are very well proportioned. It appeared finally that the exhaust back pressure is very low, as was furthermore

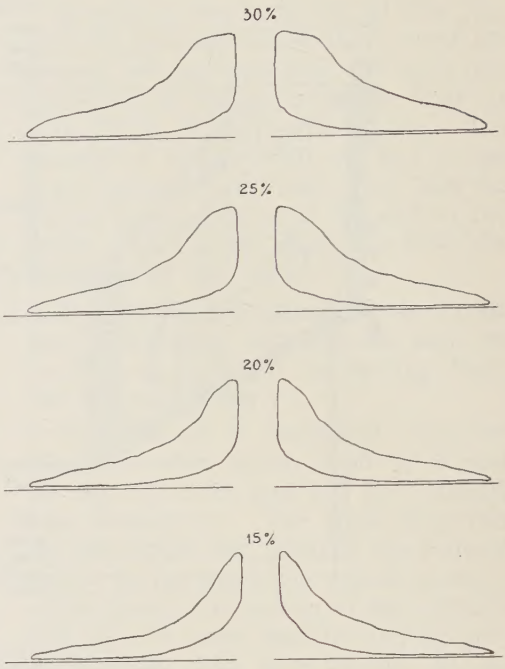

Fig. 8.

shown by direct measurements, which, however, as a rule have to be interpreted with care.

Piston, cross head, connecting rod. — The pistons are of semi-hard forged steel of conical shape and have three rings of special metal. They are quenched and tempered with a view to raising the elastic limit as much as possible with the dual object of lightening the weight and obtaining better assembly on the rod, which is also of semi-hard heat-treated steel.

This weight lightening question was considered as a first essential, but only metals of proved worth were used. The piston, with a diameter of 480 mm. (18 7/8 in.) weighs less than 60 kgr. (132 lb.), for a pressure of 18 kgr./cm².

The rod, which is 91 mm. (3 37/64 in.) in diameter and is a little longer than 1 m. (3 ft. 3 3/8 in.) between the crosshead and piston, is extended by a tail rod 75 mm. (2 61/64 in.) in diameter. The rod and tail rod are bored with a 30 mm. (1 3/16 in.) diameter hole to within 30 mm. (1 3/16 in.) of the crosshead cone. The total weight of the piston, rod and tail rod and the piston fixing nut is only 168.7 kgr. (371.9 lb.).

The tail rod is carried in front by a closed guide as is the usual practice on the Belgian Railways. The arrangement, however, which includes a bronze bush mounted with play in a cast iron sleeve, has been improved by eliminating play so that the two details are concerned in the bending brought about by the support of the tail rod. In addition, cast iron with a nickel content having a greater capacity for deadening bending oscillations has been used in the place of phosphor bronze.

The piston rod packing is of the « Crescent » type, of bronze containing about 65 % lead.

The crossheads are of cast steel with a minimum tensile strength of 50 kgr./-mm² (31.75 tons/sq. in.). They are of the single guide type which is less bulky than those with double guides. The blocks were made 540 mm. (21 5/16 in.) long and 140 mm. (5 1/2 in.) wide in order to avoid exceeding a specific pressure of 6 kgr./cm² (85.3 lb./sq. in.) on the top slide bar. To keep the weight down as much as possible, it was necessary to reduce the size of the guide, and this was done by spacing to the minimum the crosshead pin from the slide bar. Spaces hollowed out in the webs help to reduce the weight so that the total weight, including the crosshead pin, is only 123.5 kgr. (272 lb.). The shoes are lubricated by means of needle type lubricators.

The slide bar is very rigid; it is 1.486 m. (4 ft. 10 1/2 in.) long between the bearing centre lines, its deflection with the maximum reaction being less than 0.6 mm. (3/128 in.) when new.

The connecting rods are in semi-hard steel, quenched and tempered. The rod is hollowed out to form a double T the web of which is only 13 mm. (33/64 in.) thick. It terminates in a forked big end in the two branches of which a stay is fitted laterally, which strongly resists bending, keeping them the correct distance apart, and a large bolt crossing from one side to the other.

Investigation into the centre of percussion on the connecting rod in relation to the centre line of its small end has determined exactly the vertical inertia forces, and in consequence, the fraction of the rod taking the effect of reciprocating movements. Its weight is 77.5 kgr. (170.9 lb.). The total weight of the parts subject to reciprocating movements is 364.7 kgr. (804 lb.). 45 % of the effect of these latter has been balanced.

Brake. — The locomotive is equipped with a 2-stage brake pump which is lighter than the bi-compound type and is sufficient for average weight trains.

The bogie is braked by a 254-mm. (10 in.) diameter cylinder, fixed to a middle bracket in the front of its one piece-frame. The push rod works on a vertical bell-crank lever.

The coupled pairs of wheels are braked by 2 vertical cylinders of 330-mm. (13 in.) diameter, with 127-mm. (5 in.) piston stroke, fixed in front of the driving axle. They exert a total braking force of 60 tons which can be reduced to half by a centrifugal self-regulator worked mechanically by one of the tender axles. This self-regulator actuates pneumatic relays in order to have a decreasing brake

pressure until a speed of approximately 80 km. (50 miles) an hour is reached.

In order to limit the pressure on the tyres to less than 15 kgr./cm² (213 lb./sq. in.) the blocks have been duplicated, thereby also increasing their individual efficiency. They are furthermore arranged symmetrically per wheel at the end of a common diameter and as near the level of the axles as the distance apart of the coupled wheels allows, in order to reduce the reaction of the braking on the suspension.

Two vertical cylinders of 203 mm. (8 in.) diameter brake the rear carrying wheels. The double blocks are arranged symmetrically about the horizontal centre line of the wheels. They exert a force of 24 800 kgr. (54 675 lb.), i. e. 130 % of 19 tons.

The stopping distances from 140 km. (87 miles) an hour of a set consisting of 5 steel coaches with a total tare of 220 t. (216.5 Engl. tons) equipped with ordinary brakes was then determined. The test was carried out on sections of line with a maximum gradient of 1 in 500. The stopping distances were 998, 1 073, 1 087, 1 124 and 1 124 metres (1 091, 1 173, 1 189, 1 229 and 1 229 yards) respectively, i. e. an average of 1 080 m. (1 181 yards), which confirmed the favourable results expected from the use of the high-pressure brakes on the locomotive and tender.

Miscellaneous fittings. — The locomotive is equipped with a « Pyram » smoke consuming device, with a « Superior » steam soot blower worked from the cab, and with a « Pyle » turbo-generator for lighting the locomotive.

The boiler is fed by two No. 11 injectors, one exhaust steam injector of the latest Davies & Metcalfe type, and the other for hot water by the same firm. The live steam necessary to work all these fittings is distributed by a fountain having 12 valves, placed conveniently for the engine men, and taking the steam from the top of the dome where it is driest.

The sanders are worked by compressed air as well as the by-passes.

The locomotive is fitted with a Teloc time and speed recorder showing and registering speeds up to 150 km. (93 miles) an hour.

Window wipers have been fitted to each of the two front windows of the cab.

Two pivoting seats are placed on the left and right sides of the cab for the use of the engine men, and are protected at the back by two sheet iron screens with a glazed look-out at view height.

Deflector. — The deflector, which gives the locomotive and tender their characteristic aspect, consists, as mentioned previously, of a front shield pierced by a longitudinal opening. The air which is swept therein flows out through the lateral outlets which are much larger than the front longitudinal inlet, which results in its speed being reduced relatively to that of the locomotive. The air flowing from the lateral outlets is then guided by large longitudinal screens. There is moreover a conversion of its kinetic energy into potential energy, thus putting it in light static over-pressure.

The efficacy of this double aerodynamic alteration is due on the one hand to the reduction of the head on resistance of the vehicle in proportion to the square of the reduction of the air speed, and on the other hand to the fact that air at slight over-pressure gives rise, in the presence of the surrounding atmosphere, to a surface of discontinuity which protects the vehicle from the friction of

the air at high speed and also removes the shocks thereof on the parts in motion.

The frictional resistance of the deflector itself remains, but this is small owing to the small area of its openings and its own head on resistance which is equally small, owing to the horizontal parabolic sections of the front shield and the absence of high pressure zones of air resulting from the opening.

The aerodynamic protection thus achieved of all the front zone is completed by the effect of the other openings placed round the cab to protect it in its turn, as well as the tender, and by the holes in the front portion of the latter (see fig. 9) which create a zone of calmer air behind.

Tender. — The coupled tender has three pairs of fixed wheels and is of the type designed about 1910 when the old *Pacific* locomotives were built. They do not differ from these except for some improvements made in view of their new use.

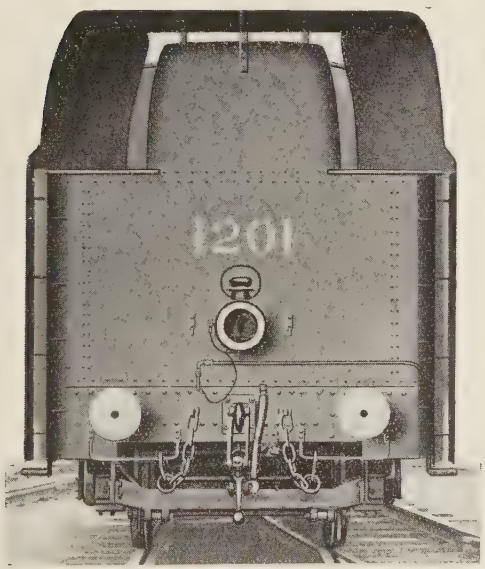

Fig. 9.

The new side sheeting in harmony with the deflector allows of easier storing of coal. The bottom of the bunker enables coal to be more easily obtained by the fireman, and the clothes chests and toolboxes are better arranged. The side filling holes are oblong, which is more convenient. The suspension, which is composed of 6 independent laminated springs, has been modified by joining the intermediate and back springs on the right and left by a longitudinal equaliser.

In order to avoid the risk of hot bearings with the usual pattern, the « Athermos » type were used instead.

A front drawgear of the rigid type has been used in place of that with helical spring.

Finally the brake shoes have been duplicated on each wheel at the level of the axle. Two 330-mm. (13 in.) diameter brake cylinders exert a theoretical force of 24 000 kgr. (52 900 lb.) giving a brake coefficient of 130 to 32.5 % of the tare, according to whether the speed exceeds 80 km. (50 miles) an hour or not, and the height of water in the tank. The speed self regulator, which has been mentioned in the description of the locomotive is, with this object in view, mounted in series with an automatic load regulator by water pressure. A three-quarter view of the tender is shown in Fig. 10.

Trials carried out with No. 1201 « Atlantic » locomotive.

The first class 12 locomotive, No. 1201, was subjected to dynamometric trials from Brussels to Ostend and Liége, hauling special express trains.

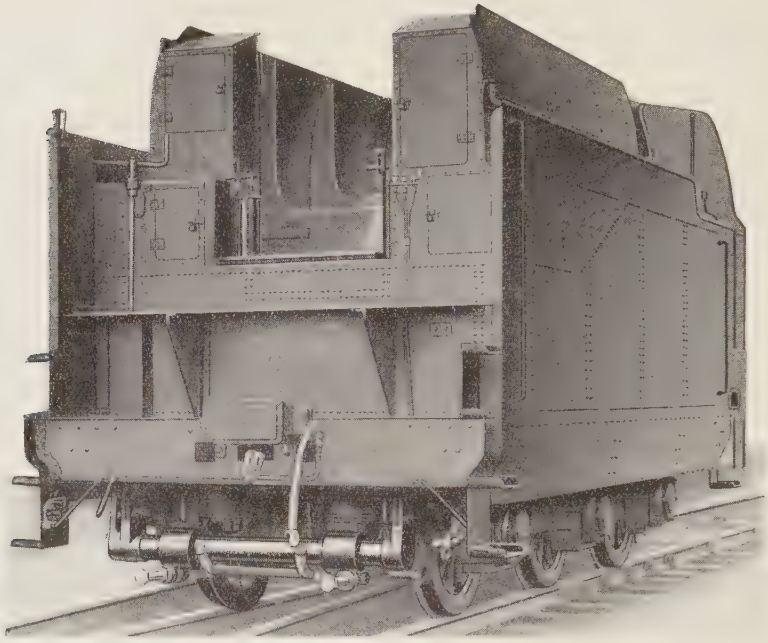

Fig. 10.

During the trials the locomotive was driven with the regulator full open at cut-offs in steps of 5 by 5 % between 40 and 15 %. Occasionally the cut-off was reduced to 10 % without any trouble being experienced as regards draught nor the behaviour of the motion.

These trials showed the following facts :—

Steam circuit. — The loss of load between the boiler and steam chest was never at any time more than 1 kgr./cm² (14 lb./sq. in.) even at the highest powers developed.

The loss of load between the steam chest and cylinders is practically nil.

Temperatures of the steam and of the gases in the smokebox. — The superheating of the steam is most satisfactory. After opening the regulator, temperatures of 380° to 400° C. (716 to 752° F.) in the steam chest were rapidly obtained when the locomotive was working at average power. Occasionally temperatures of 415° C. (779° F.) were recorded.

Notwithstanding these high temperatures at which steam was admitted to the cylinders, the exhaust temperatures hardly exceeded 140° C. (284° F.). On the other hand the gas temperature in the smokebox was approximately 320° C. (608° F.).

Power and drawbar tractive effort. — During the trials, as the boiler never failed to give the steam required, the maximum power has not been attained. On the one hand, no more than 11 steel coaches weighing together 400 t. (394 Engl. tons) were hauled and on the other

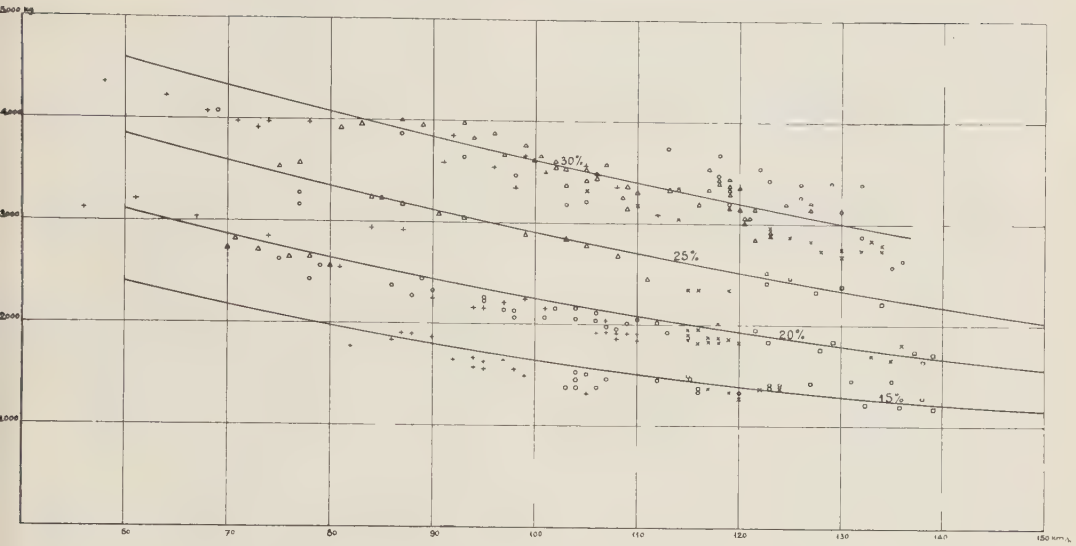

Fig. 11.

the speed had to be kept within the maximum authorised limits.

The highest drawbar horse-power recorded during the various trials was 1 750, wich corresponds to an indicated H.P. of approximately 2 700.

The tractive efforts recorded at the usual cut-offs are shown in the graph, Fig. 11.

Rolling resistance. — The rolling resistance with the regulator closed is not more than 10 kgr./t. (22.4 lb./ton) at 120 km. (75 miles) an hour and 12 kgr./t. (26.9 lb./ton) at 130 km. (81 miles). The total resistance of the locomotive is nearly half less than that of the old *Atlantic* locomotives which were 20 % lighter. An appreciable part of this result is due to the streamlining.

Fuel consumption. — The table hereafter gives the characteristic results of the dynamometric tests carried out on the 30th June, 1939, on the Ostend-Ans line, approximately 204 km. (126.8 miles) long with two ridges 40 m. (131 ft.) and the point of arrival 170 m. (558 ft.) higher than the point of departure :—

Tare of the 7 vehicles hauled	284 t. *(279.5 Engl. tons).*
Time taken	114 minutes.
Power developed	1 790 H. P.-hour.
Total coal consumption, approx. 8 000 calories *(14 400 B. T. U./lb.)*	2 408 kgr. *(5 309 lb.).*
Consumption of coal per H.P.-hour	1.345 kgr. *(2.965 lb.).*

The locomotive was driven with the regulator fully open whilst covering practically equal runs with cut-offs of 30, 25 and 20 % respectively, which allowed attention to be paid to the mechanical efficiency which had been previously computed for these notches and at various customary speeds. The

indicated power was estimated by considering partial runs covered at constant cut-off and at a speed sufficiently uniform for the same mechanical efficiency to be ascribed thereto.

The total indicated work which results from this method of calculation is 3 202 H.P.-hour, to which a coal consumption of 0.75 kgr. (1.65 lb.) per I. H. P. corresponds.

The method of calculation of the indicated H.P., by ascribing to the locomotive, during the same partial runs, the resistance it would have shown with the regulator closed, shows a fuel consumption of about 0.8 kgr. (1.76 lb.) per I. H. P., which value is too high as the amount of work done is underestimated.

The closeness of these two values of the consumption is, in our opinion, conclusive.

In addition, when the same methods were applied during the trial on the 28th June over the same run, but with 335 t. (330 Engl. tons) tare and 30 % cut-off for two thirds of the run on account of the inertia to be overcome with this load, the work was shown to be 3 600 or 2 985 H.P.-hour respectively. For a fuel consumption of 3 207.5 kgr., the specific consumption is 0.89 or 1.07 kgr. (1.96 or 2.35 lb.), very good values for so early a cut-off. The corresponding hourly fuel consumption was about 500 kgr./m^2 (102.4 lb. per sq. foot) of grate area.

* * *

In conclusion, the new *Atlantic* locomotive can be classed amongst the most interesting European express locomotives for trains of average weight.

It can pull very economically and easily the fastest trains on the Brussels-Ostend and Brussels-Liége lines.

[621. 392 (.44), 621. 138.5 (.44) & 625. 26 (.44)]

Electric resistance welding in the rolling stock repair shops of the French National Railways Company

by R. LABORIE,

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(*Revue Générale des Chemins de fer.*)

The incessant improvement of railway rolling stock has subjected it, especially since the 1914-1918 War, to increasingly severe working conditions.

Under such conditions the maintenance of this stock could not be carried out exclusively with old fashioned methods, and for many years new ideas regarding methods of repair and even construction have been under consideration.

The improvement in technique due to developments in science and industry has, fortunately, enabled new processes to be used, the necessity for which has become more imperative each day in order to satisfy the increasing needs of maintenance services.

Undoubtedly the methods used previously in railway shops which were usually well adapted to the needs of the moment, could to-day no longer satisfy

the conditions of economy and speed now necessary to maintain locomotive and carriage stock, the complexity of which is no small tribute to the progress made.

Apart from the rational organisation of work, which, for some years, has been applied in most railway shops, the technical progress in perfecting the many forms of autogenous welding should be placed in the forefront.

Whether it is a question of oxy-acetylene or electric arc welding, braze welding, or resistance welding, progress has been incessant and has made possible a marked transformation in methods of repair.

Amongst the various processes there is one which calls for special mention because of the important change which its use has brought to maintenance workshops during the last few years, i. e. electric resistance welding, which, at present, is specially favoured in certain shops of the French National Railways Company.

This favour is justified by the considerable reduction in net cost with this method, and also the ease with which it can be adapted to very varied work.

Although it is now very well known and appreciated in France and the process has often been explained in books and periodicals, it was deemed useful to report its development in railway workshops and to draw attention to some of the most interesting applications it makes possible at the present time.

Principal characteristics of resistance welding.

As the process is to-day well known to all technicians it would be superfluous to define the principle here or to give particulars of the various types of welding machines, which are to-day widely used by the industry.

Resistance welding can be carried out in two different ways according to whether the details are to be assembled by placing one piece on the other, as in riveting, or by placing them end to end.

In the former case the current is brought by two electrodes which, on contact with the pieces, determine the welding point.

This method is called « spot welding » or « lap welding » (fig. 1).

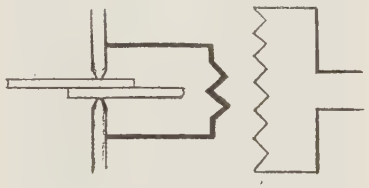


Fig. 1. — Diagram showing the principle of the lap-welding machine.

In the other case the pieces to be welded are placed end to end and each tightened in copper jaws which are used as electrodes. The function of the machine is to hold the pieces to be welded, bring the current and exert the necessary pressure on the two pieces to be joined.

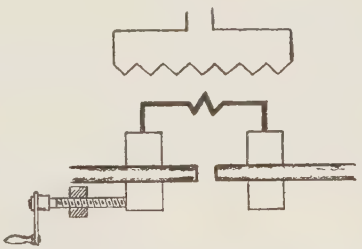


Fig. 2. — Diagram showing the principle of the butt-welding machine.

This method called « butt welding » (fig. 2) is that which will be described below.

History of electric resistance welding in the works of the former Paris-Orléans Railways.

Since 1923, in the Périgueux shops of the Orléans Company, locomotive boiler

smoke tubes with diameters of 45 mm. to 55 mm. (1 49/64 to 2 3/16 in.) inclusive, have been electrically welded with a machine of French construction.

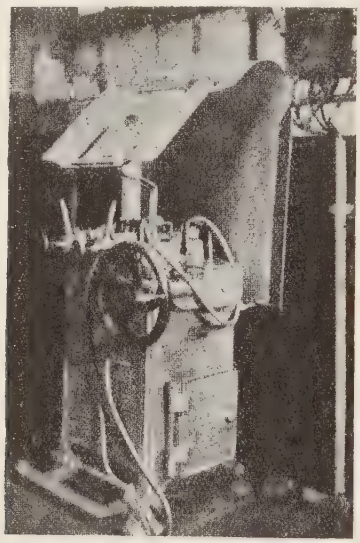


Fig. 3. — Welding machine (1923).

As is known, the essential feature in the repair of these tubes is the welding of a piece of new tube to one of the ends of the old tube in order to restore it to the correct length.

This innovation was, therefore, of real interest because of the large number of tubes to be repaired annually.

The excellence of the electrical method encouraged the Company to extend the use of welding to the large superheater tubes (diam. 133 mm. = 5 15/64 in.; thickness 4 mm. = 5/32 in.), and in 1929 these works obtained a welding machine capable of welding a section of 3 000 mm² (4.65 sq. in.) (fig. 4).

As soon as this machine was put into service, it was seen that if used exclusively for the repair of large tubes it would be only partially employed.

The idea of using it for welding forged details, therefore soon obtained.

After very severe mechanical tests on various steel sections of many different grades, the results obtained, in tension, bending and resiliency, showed that safety could be guaranteed with this process.

These tests, in addition, showed the possibility of obtaining excellent welds with heterogeneous steels. Thus the welds of test pieces consisting respectively of 70 and 40-kgr. (44.4 and 25.4 tons/sq. in.) steels on the one hand, and 90 and 40-kgr. (57.1 and 25.4 tons/sq. in.) on the other, were able to resist fracture during tensile tests, the fracture occurring in every case away from the weld and in the 40-kgr. (25.4 tons/sq. in.) portion.

It was then decided that most of the details for the Company's rolling stock could be welded so long as the section was within the capacity of the machine (3 000 mm², i. e. 62 mm. or 2 7/16 in. round).

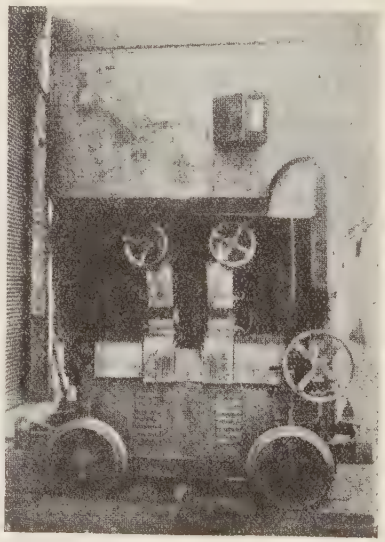


Fig. 4. — 3 000-mm² (4.65 sq. in.) welding machine (1929).

Taking into consideration the systematic tests undertaken and the experience gained later with this welding machine, which had shown the possibility of extending the process to larger details, the Orléans Company decided to purchase a machine capable of welding 5 000 mm² (7.75 sq. in.) continuously, and occasionally 6 500 mm² (10.075 sq. in.) (fig. 5).

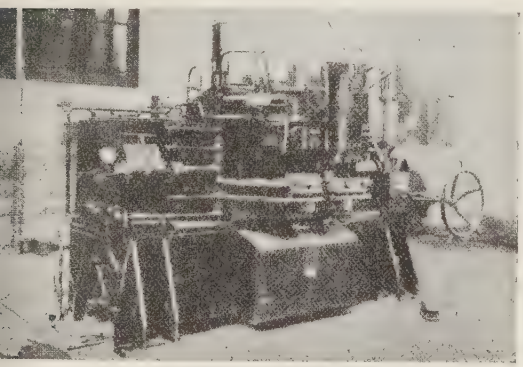


Fig. 5. — 5 000-mm² (7.75 sq. in.) welding machine (1935).

Such a machine should be able to weld most parts of railway equipment generally repaired in the Company's workshops, and experience has shown that it can do so.

Investigation into the best method of welding.

Butt welding can be carried out in three ways :

(1) by contact,
(2) by flash,
(3) by a combination of contact and flash.

As previously mentioned resistance welding had, from the beginning, been carried out on locomotive smoke tubes. At that time the industry had very limited experience with butt welding and the contact method was generally used. This latter being considered impracticable on tubes, it was necessary to substitute the flash method.

It is well known that this process consists in slowly bringing the parts in contact until numerous arcs spring between them which produce a large volume of flashes. Through the effect of these bad contacts, the metal disintegrates causing a rise in temperature until fusion is reached.

The advantage of this method was obvious from the beginning as it alone enables the tubes to be correctly welded, and this could not be done by the contact method.

In addition, the numerous comparisons of welded test pieces with solid bars showed that the flash process totally eliminates the inclusion of oxide, which is sometimes found with contact welding.

Moreover, as the anticipated benefits from the building up of metal obtained by contact welding were not confirmed by the test pieces, this latter method was abandoned in favour of the flash method.

It should be noted that although this method has the disadvantage of a small loss of material and the formation of inconvenient flashes, it has, on the other hand, the advantage of reducing the time taken for the operation, uses less energy and does away with enlargement at the weld, as the bulge produced only consists of rather brittle projections which can be easily removed by simple chiseling.

The reasons why the flash method was favoured by the Orléans Company since the commencement of welding with low powered machines have thus been examined.

Later, when large superheater tubes (outside diameter 133 mm. = 5 15/64 in.) could be welded with a more powerful machine, this preference increased. It was realised that because of the thickness of these tubes (4 mm. = 5/32 in.) it was possible to use the contact me-

thod for short periods and very rapidly bring the parts to be welded to a high temperature without, however, attaining fusion, which would have brought about the deformation of certain points of the tube periphery, as was originally the case.

The mixed method thus constitutes an improved form of the flash method.

As the dexterity needed for this method is easy to acquire, it was decided to use only mixed welding for all tubes or plain bars of appreciable section.

It was also noted from experience that the practice of annealing after welding was beneficial, and this was systematically carried out whatever the nature of the metal welded.

It should be noted, moreover, that in opposition to the belief still fairly widely held, it is not necessary, with flash or mixed methods, to prepare the section to be welded. Thus all rough bars are sheared or oxy-cut without subsequent machining and the saw is only used when it is necessary to cut pieces already machined which, if sheared, would deform or deteriorate.

It is, of course, understood that when shear cut, all welding is commenced by a period of flashing, with the object of matching perfectly the two edges in contact.

Systematic trials with a view to the extended use of the process.

As has been shown, the development of resistance welding in the workshops of the Orléans Company, was continued until the Company had a machine of 3000-mm² capacity with which very varied details could be welded.

Although the results in service of the details thus repaired were encouraging (these were carefully marked when repaired), it appeared necessary, in view of the extension of the process to important details upon which depended the safe working of rolling stock, to undertake systematic welding tests to be checked in the laboratory.

These tests were of additional interest as they disproved the theory, which is still prevalent in a large number of administrations and mechanical workshops, that the welding of mild steel alone was practicable.

They were carried out in conjunction with the laboratory of the Orléans Company (1) and they showed that the welding of all types of details was possible, without impairing the factor of safety allowed for these details, when designed.

Tables Nos. 1, 2 and 3 (mechanical tests), and Plates I, II, III, IV (micrographs) and V, VI, VII, VIII (macrographs) which are appended show the average results obtained on numerous test pieces prepared in the shops. The mechanical results, for the two processes used (contact and flash), show the high quality of the test pieces, which is well confirmed by the examination of the different macrographs and micrographs.

It should be noted, however, that although the line of joining appears (macrographically) completely desulphurated, in the case of flash welding, there is a slight superiority in favour of this method, especially when the welding is followed by annealing. This superiority justifies the preference which flash welding has always enjoyed at the Orléans Company's workshops since, in addition to its own qualities, it ensures the exclusion of oxide from inside the weld.

On the other hand, the results obtained with the test pieces of semi-hard steel of grade E [Tensile = 55 kgr./mm²

(1) We should like specially to thank M. Le Thessier, Inspector of the French National Railways Company, for his valuable collaboration during the tests carried out in the laboratory of the Orléans Company and also his assistants, Messrs. Cirous and Estreguil, for the numerous micrographs and macrographs which they took and interpreted.

(34.9 tons/sq. in.) — E = 20 %] were such that the opinion previously mentioned concerning the precariousness of welding steels other than those of the mild type were completey refuted.

In the same way it has also been proved that not only can two details in hard steel [T = 90 kgr. (57.1 tons/sq. in.) — E = 8 % grade] be welded together, but even details of different types of steel, mild steel to high-speed steel for example (See tests of welding B steel on E steel).

The general results of these tests have, therefore, shown in an indisputable fashion, that the capacity of the welding machine is the only factor limiting the use of the process, for the repair of all details, including those called safety details.

Some examples of welding.

So far the history of resistance welding in the workshops of the late P. O. Company has been traced, where it was possible to follow the development of the process from personal experience.

It should be noted, however, that this method of welding has, for some years past, also been adopted by the workshops of the different French Railways, where it has found an extensive field of application.

Amongst the large variety of details which it has been possible to repair or remake as new, the following examples only have been included as those which appear most typical because of the character of the details concerned. In the past it had always been considered that these details should never be welded owing to the nature of their duty on rolling stock.

Locomotive adjusting spring hangers (fig. 6).

These details act as liaison between the springs and the underframes of the locomotive, tender, or coach. In fact, it is these which support the total

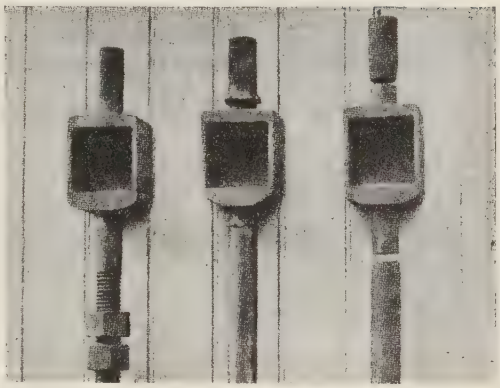


Fig. 6. — Adjusting spring hanger.

weight, the number varying according to the vehicle.

The fatigue of these details is, therefore, important, as in addition to the static force to which they are normally subjected, the forces resulting from the various shocks when running are added.

A large number of these spring hangers have a box, and in service, the screwed portion alone is subject to wear. As there can be no question of replacing these details, which are very costly, or repairing them by reducing their diameter, in order to thread them afresh, it is apparent that the only possible method for an economical repair would be that of replacing the rod by electric resistance welding.

By this process many thousands of these details have been made good in the workshops where this work has been centralised for the whole of the depots in the Area in question, without any trouble being experienced in service.

Slide valve buckles (fig. 7).

The duty of this detail in all steam locomotives is well known. It controls to a great extent the easy running of the engine, and therefore requires a toughness which can only be obtained by

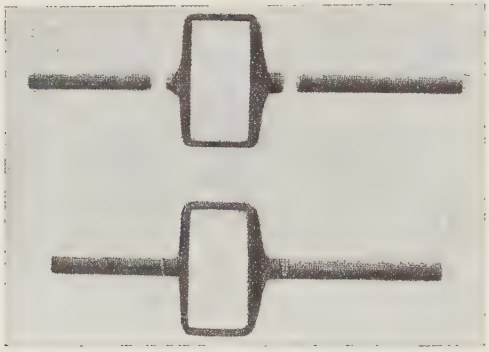


Fig. 7. — Slide valve buckles.

forging, despite its very unusual shape which entails a high cost of manufacture.

For these reasons the repair of the buckles, when worn, has always been difficult at repair shops.

Previously these details were made of 40-kgr. (25.4 tons/sq. in.) steel, but owing to the rapid wear which the rods sustained through friction in the packings, these details are now made of 48-kgr. (30.5 tons/sq. in.) steel.

It was, therefore, advantageous to be able to resistance-weld steels of different grades, in order to replace the rods of old buckles of 40-kgr. steel (which were worn to the limit) by new ones of 48-kgr. steel.

This operation has been succesfully carried out for the past 10 years.

Coupling rod end straps (fig. 8).

Figure 8, which shows the parts making up a locomotive coupling rod, brings out the role which the straps play on the rod.

As the straps are attached to the rods by means of screwed extensions, all the force which the rod sustains is transmitted by the screwed portions which, in time, wear, necessitating their repair.

The repair of the rods previously consisted in turning down the threads

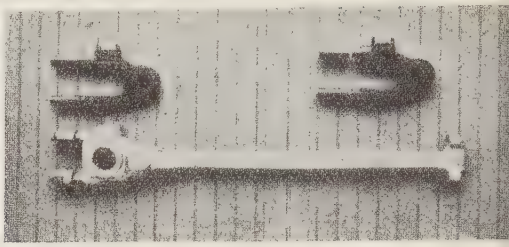


Fig. 8. — Coupling rod and strap.

on the lathe and rebuilding to the original diameter by means of a blowpipe.

This method has been very much simplified as now the worn extensions are replaced by new ones which are screwed after welding.

The repair of all the coupling rods of an Area can be centralised in one workshop in the same way as mentioned above for spring hangers, and approximately 50 per month have been so treated for many years past without a single failure being reported up to the present time.

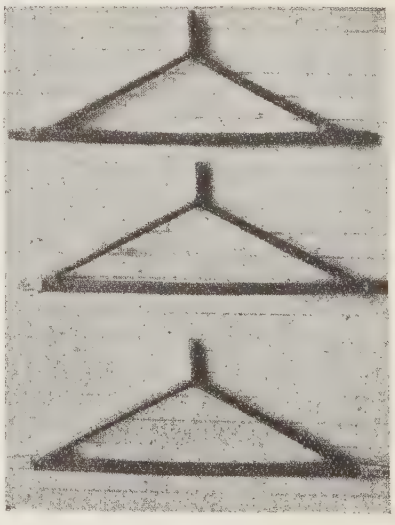


Fig. 9. — Brake truss bars.

Brake truss bar ends (fig. 9).

The wear on the brake truss bar which carries the brake shoes on each side occurs largely at the two ends.

The old method of repair consisted in building up the worn parts to their normal diameter by means of a blow pipe or arc welding.

The electric welding machine has simplified the problem by enabling new ends to be substituted for the worn ones. To this simplification of mechanical work has been added another, of no less importance, namely, the case-hardening and quenching of the ends. Originally when the ends were reformed, it was necessary to case-harden them. This operation, however, was not easy to carry out as owing to the shape of the details the extremity alone had to go into the furnace. In addition, as it was necessary to harden the two ends of one truss bar, one after the other, the operation took a fairly long time to carry out. With the new process the ends are welded on after having been previously machined, case-hardened and quenched.

Draw hooks (fig. 10).

The duty of this characteristic part of railway rolling stock is well known. As an essential safety detail it has always been subjected to very strict regulations regarding its repair.

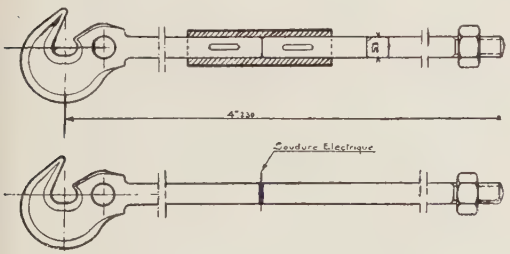


Fig. 10. — Draw hook.

Note. — Soudure électrique — electric weld.

As some hooks are fitted with very long shanks, it has been possible to substitute resistance welding for the only method previously permitted, i. e. coupling sleeve and cotters.

The welding of the hooks can now be regarded as a standard practice and the substantial economy obtained is so evident that statistics have not been compiled.

Driving piston rods (fig. 11).

The piston is the true driving detail of the locomotive. It receives the maximum force developed by the engine.

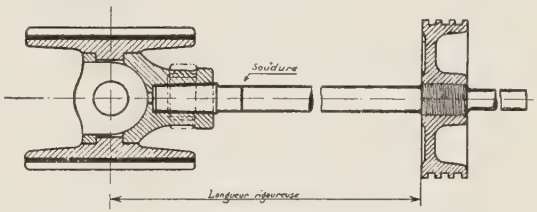


Fig. 11. — Driving piston rod and its crosshead.

Note. — Longueur rigoureuse = absolutely correct length.

This elementary consideration is sufficient to explain the particular care always taken by builders and repair shops to obtain these details from perfectly homogeneous bars of steel.

Moreover, as the piston is a detail which wears rapidly, it has to be periodically inspected, which frequently necessitates removing the crosshead.

This explains why, under the effect of the forces in service and the need for taking off the crosshead at frequent intervals, the rod penetrates more and more deeply into the crosshead. This progressive penetration reduces the useful length of the rod, which it is particularly desirable to avoid.

With this object in view the method of repair usually followed in railway shops consists in replacing the rod or building up the cone by welding on metal.

The latter method has given good results on the whole, but in spite of the care taken in annealing after welding, the various Areas still report fractures

of the rods in service near the built-up cone.

It appeared interesting to test a new method of repair which was to weld a conical portion on the end of the rod.

This test was commenced two years ago and since that time 10 welded piston rods have been placed in service on moderate-power locomotives, and at the frequent and systematic inspections of these rods no adverse comments have been made.

There is no doubt that the results of this test will shortly be considered entirely satisfactory, and the method standardised for pistons of all types of locomotives.

Tools.

In this paper the manufacture by welding on the ends of cutting tools of all descriptions used on the usual machines, such as shaping machines, planing machines, ordinary lathes, tyre turning lathes, will not be dealt with as this method has been used generally for a long while in the shops of the constituent railway companies.

Two methods of manufacture only, which appear the most interesting, will be mentioned specially, i. e. those of the milling cutters and screw cutters.

(a) *Milling cutters.*

Railway shops make ample use of cutters of the type shown in fig. 12, on vertical milling machines.

The cutter is attached to the spindle of the machine by means of the conical end without the additional security of a back centre at the cut part end.

Owing to this method of attachment, the tool is subjected to heavy stresses at the point where it is fixed in the machine, especially with the large cuts usually made by the cutters when machining certain forged parts such as connecting rods and axleboxes.

As the cutter is the only wearing portion of the tool, it was decided to make it in two parts, the cone end in 70-kgr.

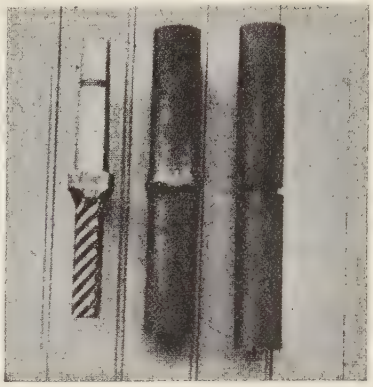


Fig. 12. — Milling cutter.

(44.4 tons/sq. in.) steel, of low value, obtained from old tyres and the cutter in high-speed steel of excellent quality. The method was all the more advantageous as the cone of the cutters for big machines often has a much larger diameter than the cut portion, which would lead to the loss of turnings of expensive steel if the cutters were made in one piece as with the old method.

(b) *Screw cutters.*

The repair of locomotive boilers necessitates the use of special very long cutters for screwing the stay holes.

Only a short portion of the total length of the tool is utilised for cutting, the other portions being used to guide or drive the tool.

As in the case of the milling cutters mentioned previously, these screw cutters are also made in two portions welded together, high-speed steel being used for the cutting end and ordinary carbon steel for the other part.

This method of manufacture was derived from the methods used previously where the various parts of the tool were joined, not by resistance welding, but by brazing or other means of assembly.

It should be noted, however, that these methods of manufacture demand particular care with regard to the heat treatment after welding, with the object of

avoiding shrinkage cracks in the neighbourhood of the weld in the transition zone wherein alloying of the two welded metals has actually taken place.

Brake pipes.

It was thought that it would be of interest to set out in this paper the method adopted by the former P. O. Company with brake pipes, when the continuous brake was fitted to wagon stock in 1928.

This work was partly centralised in one special yard where a total of approximately 30 000 wagons were equipped.

Amongst the questions which arose when the method of carrying out the work was being decided upon was the provision of 26/34 mm. (1 1/32 — 1 3/8 in.) solid drawn weldless pipes which constitute the main brake pipe of the vehicles. There appeared to be two methods of obtaining this supply :

(1) To buy pipes of exact length for the numerous types of vehicles to be equipped.

(2) To obtain pipes of commercial length, which would then be cut to suit each type of wagon.

Although the first method had advantages over the second from the practical point of view, it had, on the other hand, the drawback of a very high cost per metre of pipe.

In addition, it necessitated a large stock of pipes of very varied lengths which had to be methodically classified, owing to the frequent variation in the types of wagons passing through the yard.

The second solution was, therefore, the better owing to its economy, but it was necessary for the pieces of pipe which were cut off to be used. The use of these pieces led to the search for a welding method which is described below.

Conditions to be fulfilled by the weld.

— To be absolutely resistant and air-tight.

— Not to have any interior ridge to prevent the passing of the regulation cork ball after the fitting of the pipe.

— To leave the interior surface of the pipe absolutely clean without traces of oxide scale attaching to the walls, in order to protect the delicate apparatus controlling the brake, the correct working of which necessitates a very great cleanliness of the pipes.

Description of the method of welding.

After various trials (the most interesting of which included blowing the inside sparks by compressed air during the welding) the following method was adopted :

(*a*) The two ends to be welded were stopped up by a pad of thick felt a little away from the section to be welded (fig. 13*a*) ;

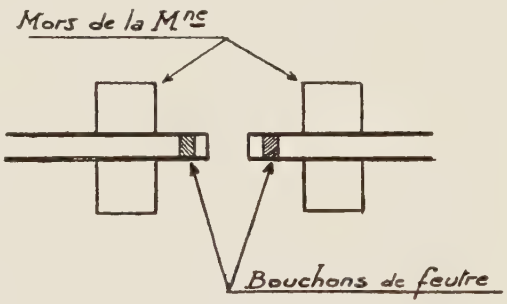


Fig. 13*a*.

Note. — Mors de la Mne = jaws of machine. — Bouchons de feutre = pads of felt.

(*b*) The weld being made by the flash process, the two felt stoppers come together and form a mass of burnt felt and oxide which become red hot during the final compression (fig. 13*b*) ;

(*c*) A punch, having a diameter 0.5 mm. (0.0197 in.) less than the inside diameter of the tube, and with a long shank, is placed in one of the two pipes to be welded near the point of welding,

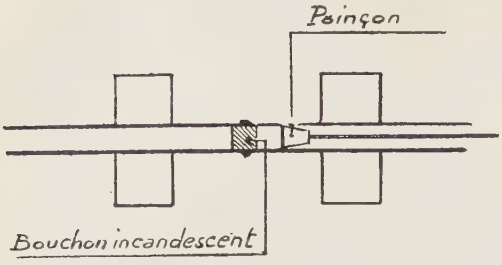


Fig. 13 *b*.

Note. — Poinçon = punch. — Bouchon incandescent = red hot pad.

the compression, effectively cutting out the oxide deposit (fig. 13*c*).

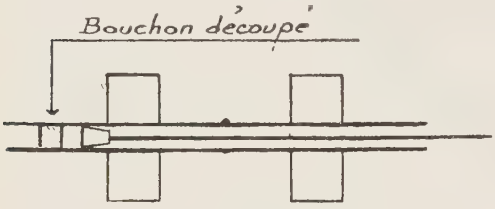


Fig. 13*c*.

Note. — Bouchon découpé = cut pad.

Results.

The surface of the pipes thus welded had the same appearance in the neighbourhood of the weld as everywhere else.

The method has allowed the whole of the pieces of tube cut off to be recovered, even the shortest, some pipes having been made, when necessary, with several welds.

When it is borne in mind that approximately 15 000 pipe welds were made by this method without the least trouble being experienced with the brake since they were put into service in 1928, it can be concluded that this method is entirely satisfactory.

Conclusions.

As has been shown, the favourable results of numerous laboratory tests encouraged the hope that resistance welding could be extended to the repair of the most important locomotive and rolling stock details without risk.

This confidence which the workshops of the French National Railways Company have placed in a new method was fully confirmed by many years experience during which no trouble whatsoever in service could be attributed to a fault in the process.

If one considers the thousands of welded details which are normally subjected to very severe service on the main lines of the Company, it must be admitted that resistance butt welding as carried out to-day in the French National Railways Company's workshops can be extended to all fields without the least apprehension, even in the case of the largest sections, both for repairs and new work.

This possible extension is largely due to the improvements in the construction of the welding machines. In the forefront of these improvements must be placed that which eliminates more and more the human element in their use, especially in connection with the heavy handling which the welding of large sections entails. The use of hydraulic, pneumatic or mechanical means of control and the increase in the degree of precision called for in numerous cases when details already machined are being worked on, place the old machines very far behind most modern ones.

The attention of the French manufacturers who for many years past have endeavoured to adapt their welding plant to our needs, is, however, drawn to the necessity for a really efficacious protection of the electrical and mechanical parts, against the showers of sparks which are still sometimes a source of great difficulty in the maintenance of the machines.

TABLE No. 1.

Mechanical tests.

Dimensions of test pieces . { Tension D = 15.96 mm. (*5/8 in.*), Bending D = 25 mm. (*63/64 in.*).

Characteristics of the steel. { B grade T.S. = 40 kgr. (*25.4 tons/in²*).— E °/₀ = 28· E grade T.S. = 55 kgr. (*34.9 tons/in²*). – E °/₀ = 20·

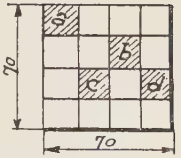
WELDING PROCESS.	Metal.	Tensile test. T. Str. kgr./mm². (tons/in.²).	Tensile test. Elongation %	Tensile test. Red. area $\frac{S - S'}{S'}$	Bending. Bending angle.	Impact. Resiliency kgrm./cm².	REMARKS.	Conclusions drawn from the results. — The tests were carried out in accordance with *UF* (*AFNOR*) methods.
Without annealing. Contact without pressure	B	42.9 (27.2)	20.85	1.45	1°	3.80	Tension. — Fractured outside weld, near the reference marks.	— Flash welding slightly decarburized the metal : slight decrease in tensile strength but elongation is increased. — Bending and resilience are definitely better with flash welding.
Without annealing. Contact with pressure.	B	40.25 (25.6)	22.20	1.71	44°	1.20	— Do. —	
Without annealing. Flash	B	40.40 (25.7)	24.40	1.76	130°	6.50	— Do. —	
With annealing. Contact with pressure.	B	40.0 (25.0)	32.20	1.82	No test.	4.8	Tension. — Fractured outside weld.	— Flash welding is definitely better (tensile strength, elongation, and resiliency much increased).
With annealing. Flash	B	42.85 (27.2)	30.0	1.19		10.10	Tension. — Fractured beside weld.	
Without annealing. Contact with pressure.	E	56.80 (36.1)	14.80	1.03	11°	4.10	Tension. — Fractured outside weld, near the reference marks.	Same remarks as with unannealed *B* steel.
Without annealing. Flash	E	54.40 (35.5)	17.85	1.45	153°	3.20	— Do. —	
With annealing. Contact with pressure.	E	54.40 (35.5)	22.20	0.46	29°	4.10	Tension. — Fractured at the weld.	Same remarks as above but the advantages with flash welding are not so great.
With annealing. Flash	E	53.35 (33.9)	23.50	0.95	155°	5.0	Tension. — Fractured beside weld.	
Flash without annealing	BE	43.25 (27.5)	18.80	1.36	No test.	4.10	Tension. — Fractured beside weld.	(With and without annealing).
Flash with annealing .	BE	42.25 (26.8)	22.20	0.92		5.0	— Do. —	Slight improvement with annealing.

TABLE No. 2.

Tensile tests.

Test pieces taken in accordance with drawing in a square of 70 mm. (*2 3/4 in.*) — ∅ of test pieces 13.8 mm. (*17/32 in.*)

Characteristics of *B* grade steel: T.S. = 40 kgr. (*25.4 tons/in²*). E % = 28.

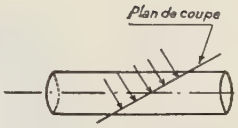


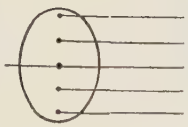
WELDING PROCESS.	Reference marks on test pieces.	Metal.	T. Str. kgr./mm².	T. Str. tons/mm².	Elongation %	Red. area $\frac{S - S'}{S'}$	REMARKS.	Conclusions drawn from the results. — The tests were carried out in accordance with *UF (AFNOR)* methods.
Without annealing. Contact with pressure.	*a*		36.35	*23.1*	27.00	1.84	Fractured outside weld near reference marks.	The steel of the test pieces marked *a* and *d* was more decarburized than the steel in the centre of the square. Greater tensile strength and less elongation results with test pieces marked *c* and *b*.
	b	B	43.60	*27.7*	18.00	0.20	Broken at weld.	
	c		41.40	*26.3*	12.5	0.22	— Do. —	
	d		36.00	*22.8*	29.0	2.14	— Do. —	
Without annealing. Flash	*a*		36.1	*22.9*	29.0	2.90	— Do. —	The average tensile strength of the steel of the flash-welded square is greater than that of the pressure-welded steel. The same remark applies to elongations.
	b	B	46.7	*29.6*	21.0	0.91	— Do. —	
	c		45.85	*29.1*	20.0	0.83	— Do. —	
	d		37.35	*23.7*	23.0	2.14	Fractured at head.	
With annealing. Contact with pressure.	*a*		32.90	*20.9*	14.0	0.32	Fractured at weld.	Annealing did not improve the characteristics of the metal.
	b	B	43.70	*27.7*	21.5	0.73	— Do. —	
	c		43.80	*27.8*	24.0	0.91	— Do. —	
	d		38.35	*24.3*	26.0	1.98	Fractured outside weld.	
With annealing. Flash	*a*		36.35	*23.1*	30.0	3.13	Fractured at weld.	
	b	B	43.40	*27.6*	17.5	0.52	— Do. —	
	c		46.20	*29.3*	28.5	0.91	— Do. —	
	d		37.55	*23.8*	29.0	2.68	— Do. —	
Unwelded bar	*a*		33.80	*21.5*	36.5	2.89	— Do. —	
	b	B	42.20	*26.8*	31.0	1.25	— Do. —	
	c		41.60	*26.4*	32.5	1.57	— Do. —	
	d		34.45	*21.9*	39.5	2.98	— Do. —	

TABLE No. 3.

Hardness test with Herbert pendulum on an oblique section

(in accordance with drawing).

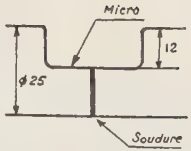


Welding process.	Metal.	Position of points.	Average hardness.	Conclusions drawn from the results. — The tests were carried out in accordance with *UF* (*AFNOR*) methods.
With annealing. — Contact with pressure .	B		158 units 161 — 183 — 150 — 135 —	Decarburization is noticed at the periphery, which is shown by a decrease in hardness. The hardness of the contact zone is higher than that of the base metals in the case of two identical metals, and superior to the milder metal when the two metals are different (without annealing).
With annealing. — Flash . . .	B		173 — 191 — 203 — 195 — 170 —	
Without annealing. — Flash . . .	E		208 — 235 — 189 — 173 — 164 —	
	B			
With annealing. — Flash . . .	E		185 — 194 — 168 — 176 — 156 —	
	B			

Note. — Plan de coupe = how test piece was cut.

MICROGRAPHS.

Test pieces taken according to opposite drawing.
Magnification: 110 diam. Etched with picric acid.



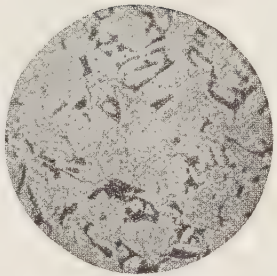
B steel { T.S. = 40 kgr. mm² (25.4 tons/in ²). E % = 8

Welded by contact with pressure.

Plate I.

Without annealing.

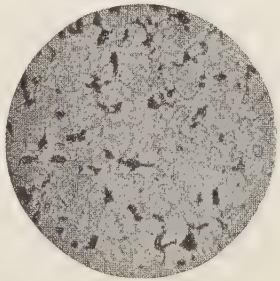
At the weld.
Intergranular structure, few or no blowholes, large grain.



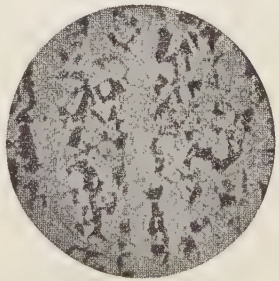
5.4 mm. (7/32 in.) from weld.
Slight trace of overheating.

11.3 mm. (7/16 in.) from weld.
Normal structure.

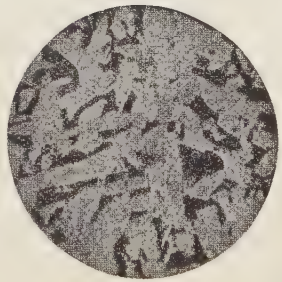
With annealing.



At the weld.
Fair amount of decarburization, few blowholes, fine grain.



5.7 mm. (7/32 in.) from weld.
Decrease in size of grain.



8 mm. (5/16 in.) from weld.
Normal structure.

Without annealing.

At the weld.
Overheated (intergranular structure). Few or no blow-holes. Large grain.

3 mm. (1/8 in.) from weld.
Overheated.

6 mm. (1/4 in.) from weld.
Normal structure.

With annealing.

At the weld.
Slight decarburization. Grain fairly large. Few blow-holes.

1 mm. (3/64 in.) from weld.
Structure practically normal.

2.3 mm. (3/32 in.) from weld.
Normal structure.

B steel { T. S. = 40 kgr. mm² (25.4 tons/in ²). E % = 28

Flash welded.

Plate II.

Welded by contact with pressure.

E steel { T. S. = 55 kgr./mm² (34.9 tons/in.²). E % = 20

Plate III.

Without annealing.

At the weld.

Overheated (intergranular structure). Large grain. Few blowholes.

1.6 mm. (1/16 in.) from weld.

Overheated. Large grain.

7.5 mm. (19/64 in.) from weld.

Normal structure. Fine grain.

With annealing.

At the weld.

Slight decarburization. Incomplete disappearance of the overheating.

3 mm. (1/8 in.) from weld.

Trace of overheating.

5.8 mm. (15/64 in.) from weld.

Large grain. Slight trace of overheating, no doubt from annealing.

E steel { T. S. = 55 kgr./mm² (34.9 tons/in.²). E % = 20

Flash welded.

Plate IV.

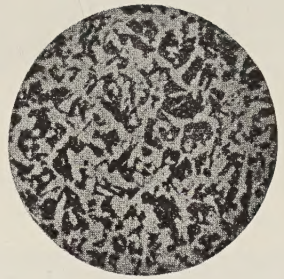
Without annealing.

At the weld.

Overheated (intergranular structure). Average grain. Few blowholes.

2 mm. (5/64 in.) from weld.

Overheated. Average grain.



3 mm. (1/8 in.) from weld.

Normal structure. Fine grain.

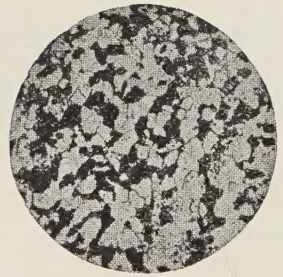
With annealing.

At the weld.

Slight enlargement of grain, weld nearly invisible.

1 mm. (3/64 in.) from weld.

Slight enlargement of grain.

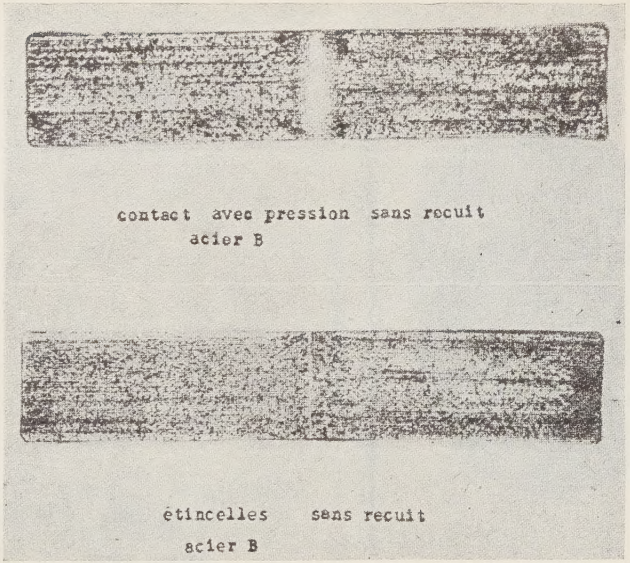


2 mm. (3/32 in.) from weld.

Normal structure. Fine grain.

MACROGRAPHS.

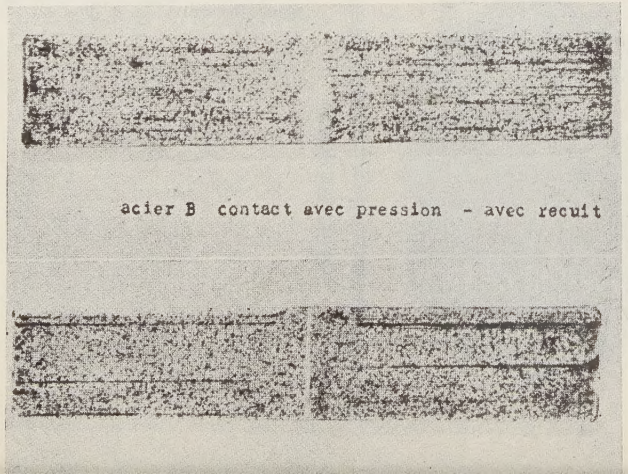
Plate V.



contact avec pression sans recuit
acier B

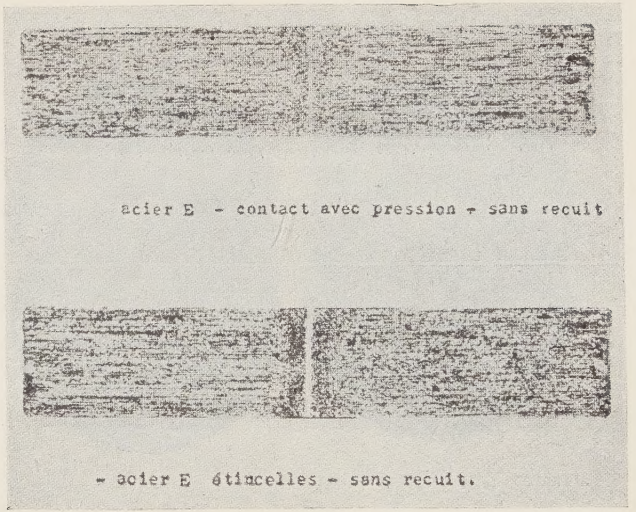
étincelles sans recuit
acier B

Plate VI.



acier B contact avec pression - avec recuit

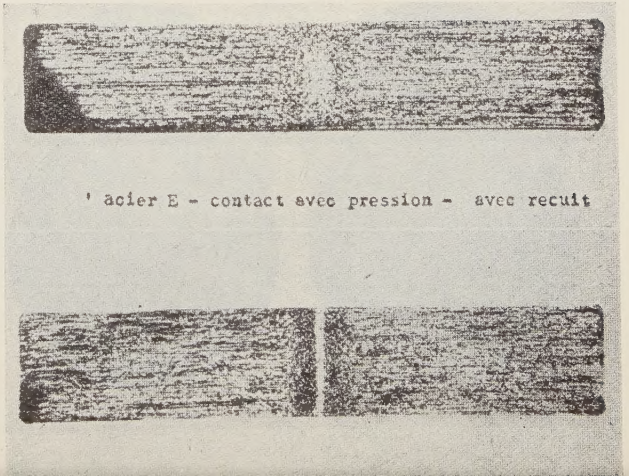
Plate VII.



acier E - contact avec pression - sans recuit

- acier E étincelles - sans recuit.

Plate VIII.



' acier E - contact avec pression - avec recuit

NEW BOOKS AND PUBLICATIONS.

[385. 61]

BESSER (Geh. Baurat Friedrich). — **Technische Einheit im Eisenbahnwesen.** Fassung 1938. Textausgabe mit Erläuterungen (*Technical Standardization of Railways.* 1938 wording. Text of regulations with remarks). A pamphlet (8 × 5 3/4 inches) of 54 pages, illustrated. — 1939, Berlin, W9; Wilhelm Ernst & Sohn, publishers. (Price, outside Germany : 1.50 RM.)

In this booklet, the Author gives the full text of the new regulations on technical standardization adopted in 1938, and comments the various provisions in succession.

The regulations in force up to 1938 dated back to 1913. It might appear surprising that no alterations were made to the same during the last 25 years, whereas the construction of railway rolling stock made considerable progress.

The object of the regulations adopted and called « Technical Standardization » is not to make detailed constructional rules. On the contrary, as pointed out by the Author, the drafters of the « Technical Standardization » wished to leave the Railways the most complete freedom as regards the design of their vehicles, contenting themselves with taking the necessary steps to ensure that vehicles transferred from one railway system to another are able to run through without difficulty.

The origin of the first Convention is briefly recalled in the preamble. It was adopted in 1886 by a Conference which laid down the limited scope of the Agreement. The 1913 revised wording remained in force after the 1914-1918 war as the result of a formal decision ranging the Railway Technical Standardization amongst the international Agreements that remained valid. The 1938 new wording is the outcome of a revision undertaken by the International Railway Union (U. I. C.), in collaboration with representatives of the Reichsbahn, in particular, and it takes the proposals of the different member Administrations into account.

As is known, the Convention applies to the railways of the European Continent, not including Great Britain, which Country, owing to its situation, is not concerned, and some other countries whose lines are not built to the standard track gauge. The Convention only relates to rolling stock — carriages and wagons — because only such stock is called upon to run on several railway systems. Locomotives, which run over foreign rails in particular cases only, are made the subject of special agreements.

The distribution of the subject matter between the various Chapters has been somewhat altered. The numbering of the paragraphs, which began anew in each chapter, now continues throughout the new text. A table shows, facing each other, the chapters and paragraphs which deal with the same matter in both texts, at any rate when such correspondence actually exists.

The provisions in connection with wagon disinfection have not been retained. Many others have been altered. Some regulations have been added regarding goods not cleared through the Customs, and the wagons in which they may be carried. Others take into account the introduction of continuous braking on goods stock, and of electric traction. The width of the transit loading gauge is increased by 5 cm. (2 in.). It is now 3 150 mm. (10 ft. 4 in.) instead of 3 100 mm. (10 ft. 2 in.). The Author explains the meaning of the formulæ giving the extent to which the width of vehicles of great length has to be decreased, and the way these formulæ are obtained. The minimum wheelbase is increased to 3 m. (9 ft. 10 1/8 in.) for vehicles built prior to 1939, and to 3.50 m. (11 ft. 5 25/32 in.) for wagons to be built, this increase being a consequence of the increase in speed.

The work is interesting in that, besides the official wording, it gives precise indications about the scope and justification of the new provisions, and also of the most important of the regulations that have been included unaltered in the 1938 text. E. M.

[385 (092]

OBITUARY

Arthur Beresford CANE, C. B. E.

Secretary of the British Railway Companies' Association (1909-1929),
Secretary of the Local Organizing Committee of the Xth Session (London, 1925)
of the International Railway Congress Association.

We heard with regret of the death on December 21st last, in his 76th year, of Mr. Arthur Beresford CANE, who was the Secretary of the British Railway Companies' Association from 1909 to 1929, an eventful period for British railways, which included the 1914-1918 War and Government control of the railways, deep alterations in the relations between the Companies and their staff and in the working hours, the formation of the Ministry of Transport, and the amalgamation of most of the Companies to form four important Systems, etc.

In his capacity of Secretary to the Companies Association, Mr. CANE was in 1925 appointed as Joint Secretary (with Mr. MARRIOT) of the British Section of the Permanent Commission of the International Railway Congress Association (Local Organizing Committee) on the occasion of the Tenth Session held in London to coincide with the British railway centenary celebrations. All those who attended the Tenth Congress paid a tribute to the organizing ability and the unbounded activity shown by the Local Committee, and in particular by its Secretaries, who largely contributed to the great success of this important Congress.

We wish to convey our sincere sympathy to Mr. CANE's family.

The Executive Committee.